Scientific Research: Process and Product. Acceptance Address for the 2000 American Chemical Society Award for Research at an Undergraduate Institution, Sponsored by Research Corporation

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Abstract: Scientific research has a twofold nature. First, the process that I've developed for mentoring undergraduates (over more than four decades, hundreds of students of whom 73 were coauthors on 155 of my more than 1650 papers to date) in carrying out the work—from the initial literature search to the process of honoring requests for reprints of the published article—is discussed. Second, the product—student presentations at scientific meetings, studies of the separation of inorganic isomers and other coordination compounds, inorganic syntheses, laboratory experiments including replication of "classic" experiments, historical studies, lecture demonstrations, reviews of books and instructional media, and other investigations—is reviewed with citation of outstanding student coauthors and their later accomplishments. Highlights of my education, mentors, and professional career are also briefly presented.

In accepting this award it's a pleasure to thank Research Corporation, the award's sponsor, which in 1955 supported my work with the first of my 58 research grants; Professors H. Harry Szmant, the late Glenn T. Seaborg, and Harry B. Gray, who nominated me; as well as the colleagues and former students, some of whom are celebrating with me today, who wrote letters of support on my behalf (Figure 1). I'm also indebted to Bill Kieffer, Tom Lippincott, Joe Lagowski, and John Moore, editors of the *Journal of Chemical Education,* in which many of my publications have appeared, and to that journal's High School Chemistry editor, Mickey Sarquis, the wife of one of my former students, who, in 1987, appointed me editor of the "Products of Chemistry" feature, which has been and continues to be a challenging and rewarding experience. I also owe thanks to the late Leo Schubert, who appointed me to my first editorial position, feature editor of the *Journal of College Science Teaching,* a position that I have occupied since 1973. I'm also indebted to Cliff LeMaster (Figure 1), editor of *The Chemical Educator*, who appointed me editor of that journal's "Chemistry and History" feature and simultaneously introduced me to online publishing. I also wish to thank my more than 140 other coauthor colleagues as well as my 73 student coauthors (Table 1) on 155 publications of my more than 1650 papers, reviews, and encyclopedia articles to date. Much of my research has involved the ferreting out of countless facts and sources, and CSUF Reference Librarian Diane Majors has performed yeoman service for me for many years. Similarly, for decades I've depended on the skillful photographic talents of Randy Vaughn-Dotta and Robert Michelotti of the CSUF Academic Innovation Center, and, last but not least, I want to thank the love of my life, my wife Laurie, a retired elementary schoolteacher with an interest in the humanistic aspects of science, who has not only provided moral support and encouragement but who has collaborated actively with me as a coauthor (Figure 2).

As practicing chemists or chemical educators, we all know that science in general and chemistry in particular have two aspects—the *process* of investigation and discovery (what scientists *do*) and the *product* resulting from that activity (what scientists *make*). The public at large usually concentrates on the second aspect of this dichotomy to the neglect of the first. The average citizen concentrates on the products of science but neglects the process that produced them.

I'm well aware of the importance of chemical products. In addition to being editor of the *Journal of Chemical Education*'s "Products of Chemistry" feature, as Contributing Editor of the "Applied Chemistry" feature of the Encyclopædia Britannica's *Yearbook of Science and the Future* for more than two decades (1978–2000), I annually introduced *YBSF* readers to the latest of such items (for example, lithium batteries, low-calorie sweeteners, low-cholesterol powdered eggs, or fat substitutes), which we now use daily and take for granted. We all consume and enjoy the fruits of science every day, but in contrast to us, the man or woman on the street usually neglects the fundamental principles of scientific thinking, which are often poorly taught and rarely employed. Therefore, through the years, in lectures or articles, whenever I've had the opportunity, I've called attention to this dual nature of science, especially in addressing nonscientific audiences and readers.

Today, however, in reviewing my more-than-four-decade career in chemistry and chemical education, I want to postulate another dichotomy using the same two terms. First, there is the *process* that I've developed for mentoring thousands of undergraduates, many of whom now occupy responsible positions in academe, industry, and government. I've discussed at length the general principles of this process in my introduction to the students of the 1972 CSUF National Science Foundation Undergraduate Research Participation Program, which I directed, and in my Acceptance Address for the 1973 California State University and Colleges Outstanding Professor Award [1], which I recently updated for inclusion in a book titled *Teaching Excellence: A Collection of Essays on College Education* [2]. Therefore, although I'll mention some of my mentoring practices today, I'll devote most of my time

 S1430-4171(00)05415-3, Published on Web 10/02/2000, 10.1007/s00897000415a, 550277gk.pdf

to paying tribute to some of my most outstanding student coauthors and their *products*—presentations at seminars and meetings, investigations in coordination chemistry, studies of the separation of geometric and optical isomers, inorganic syntheses, laboratory experiments including modification of "classic" experiments for use in undergraduate chemistry courses, historical studies, lecture demonstrations, and reviews of books and other instructional media. I also wish to acknowledge my own mentors, who have played crucial roles in inspiring and facilitating my career. In all sincerity, I can say that without the help of all these individuals, I would not be standing before you today.

Research as an Outgrowth of Teaching

Although in some circles research and teaching are sometimes considered as opposed, incompatible faculty functions, my research has always been an adjunct of my primary interest—teaching—rather than a goal *per se*. Most of my research projects and publications have evolved from work carried on in my regular classes. Because equipment and supplies have been scarce and because my time available for research has been limited, I've tried to pursue a realistic research program consistent with the functions and aims of my university. Thus, I've attempted to augment our supplies by seeking outside support in the form of grants. Most of these funds, however, have been used to pay student assistants, permitting them to finance their university studies while gaining experience in their chosen field. I feel that it is in original research that students can best develop the ingenuity and practical application of principles that are a *sine qua non* for a successful career, not only in science but also in any field calling for independent thought. In short, I've tried to maintain a suitable balance between the transmission of current knowledge and techniques by teaching and the creation of new knowledge by student research.

I attribute my success to my excellent early education at the Central High School of Philadelphia, one of the nation's oldest elite academic secondary schools, and the examples provided by my early role models. Although I've worked in depth in a few fields such as coordination chemistry, some colleagues have characterized me as a Renaissance man and the "Isaac Asimov of chemistry" because of my wide interests and great prolificacy. However, I prefer to think of myself as a scientific dilettante. Because I don't work at a primarily research institution, I've enjoyed the luxury of working on whatever happened to strike my fancy. While to some extent my account will be necessarily personal, I hope that this "trip down memory lane" will be of general interest, will illustrate some general principles, and may even resonate with some of your own experiences.

My Introduction to Chemistry

During my sixth year, I became intrigued with the fascinating world of chemistry, and I informed any of my relatives who would listen of my desire for a chemistry set. On my seventh birthday, my Uncle Si and Aunt Pauline (Figure 3), presented me with an A. C. Gilbert Chemistry Set No. 1 (price $1 at a time when a dollar would purchase 20 hot dogs on buns with mustard, relish, and sauerkraut, and when a complete lobster dinner cost 85 cents). From that moment, there was never any question as to my future career: I was hooked on chemistry—the central science. My experience is hardly unique. In fact, it's similar to that of numerous chemists. It is indeed unfortunate that in our era of excessive concern with possible litigation and damage to the environment, the chemistry set, that traditional rite of passage and entry into the profession for so many of us, has virtually disappeared.

I've detailed my personal life, including childhood, adolescence, and secondary, undergraduate, and graduate school experiences when I received the George C. Pimentel Award in Chemical Education in 1993, and my acceptance address has already been published [3]. Therefore, here, I'll confine my remarks to my experiences with mentors during my formative years and to their effects on the various aspects of my research activity with my own students.

Undergraduate Studies

Because at the age of seventeen I matriculated at the University of Pennsylvania in February rather than in September of 1948, I could not enroll as a Bachelor of Science (B.S.) candidate but instead had to enroll as a Bachelor of Arts (B.A.) candidate. Although this situation was purely fortuitous, I realize in retrospect that it was a lucky choice, for I was exposed to a wider curriculum of liberal arts subjects not usually taken by most chemistry majors. I feel that this not only enriched my enjoyment of life but also made me a better teacher. I was also extremely lucky in having Lou Baker, now Professor Emeritus of Chemistry at Georgetown University, as my teaching assistant in general chemistry (Figure 4). After allowing me to carry out some preliminary experiments on crystal growing with copper(II) sulfate pentahydrate, Lou introduced me to coordination chemistry by allowing me to work in his private laboratory as a freshman.

The first complex compound that I prepared, which I labeled "compound α, May 7, 1948," was the versatile intermediate, carbonatotetraamminecobalt(III) nitrate hemihydrate, $[CoCO_3(NH_3)_4]NO_3 \cdot ½H_2O$ (Figure 5), and I still keep the bottle on the shelf by my desk as a souvenir (Figure 6). Lou thus weaned me (but not completely) from adolescent pyrotechnics to coordination chemistry, and in gratitude I dedicated my first book *Alfred Werner: Founder of Coordination Chemistry* to him (Figures 7 and 8).

Lou exerted a profound influence on another aspect of my career—my writing ability. For some unfathomable reason, I had convinced myself that I was unable to write, and in my freshman English composition class I suffered from a chronic case of "writer's block." Three days after I had prepared compound α in Lou's lab, I wrote a composition describing the experiment. Because Lou had ruined the first run when his jury-rigged electric fan intended to accelerate evaporation of the mother liquor came crashing down onto the 3-liter evaporating dish, I referred to him under a pseudonym to protect his reputation. The composition received an "A," my case of writer's block was cured, and henceforth I wrote about scientific subjects—with great success. I now realize that I was merely applying the well-known maxim of writing on subjects with which I was familiar, but Lou served as the catalyst for my transformation from hesitant amateur to prolific author.

Figure 1. Symposium participants Jerry L. Sarquis, Morton Z. Hoffman, Bassam Z. Shakhashiri, Richard A. Houghten, Jr., George B. Kauffman, Harry B. Gray, Mary Virginia Orna, Clifford LeMaster, Robin D. Myers, and Louis C. W. Baker (left to right), Award for Research at an Undergraduate Institution Symposium, 219th National Meeting, American Chemical Society, San Francisco, California, March 28-April 2, 2000. Photograph by Ernest Carpenter. (Reprinted with permission from the American Chemical Society.)

Figure 2. George and Laurie Kauffman and award plaque. (Courtesy, Randy Vaughn-Dotta, photographer.)

Figure 3. George B. Kauffman with uncle and aunt, Mr. and Mrs. Simon Fiedel, about 1940. (Courtesy, George B. Kauffman.)

Figure 4. George B. Kauffman (left) and Louis C. W. Baker (right), Award for Research at an Undergraduate Institution Symposium, 219th National Meeting, American Chemical Society, San Francisco, California, March 28-April 2, 2000. Photograph by Ernest Carpenter. (Reprinted with permission from the American Chemical Society.)

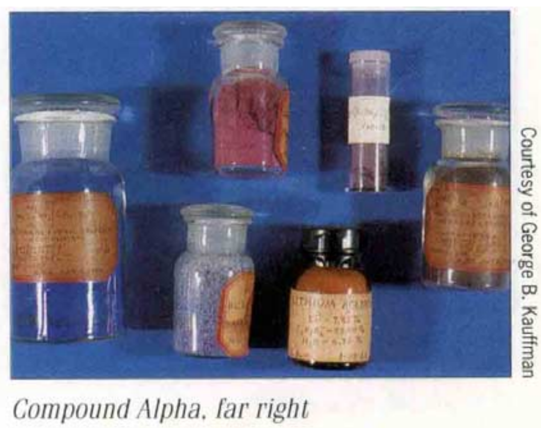


Figure 5. George B. Kauffman's coordination compounds, 1948. Compound Alpha on far right. (Courtesy, George B. Kauffman.)

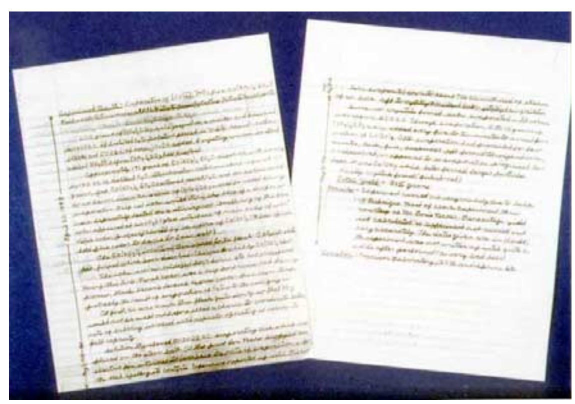


Figure 6. George B. Kauffman's laboratory notebook, April–May 1948. (Courtesy, George B. Kauffman.)

I try to repay my debt to Lou by customarily giving several of my freshman chemistry students special research projects in the belief that early discovery and encouragement of talent is one of a teacher's most important functions. I've worked with junior high and senior high students, and Jim Felser, a coauthor who worked with me when he was only fifteen, later became a medical doctor, Research Professor at the George

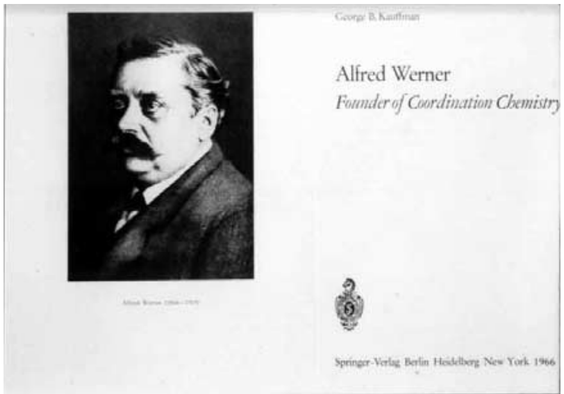


Figure 7. George B. Kauffman's first book, title page, 1966. (Courtesy, Springer-Verlag.)

To Dr. Louis C. W. Baker,

who as a young and patient instructor of freshman chemistry at the University of Pennsylvania, once took the time and effort to initiate the author into the amazing mysteries of the octahedron and so demonstrated to him that the carbon atom possesses no monopoly on stereochemistry.
Lou Baker received his doctorate under Prof. Thomas P. McCutcheon, who had worked with Werner in Zürich. Thus, the author is pleased to claim a direct, even if highly tenuous, academic link with the Master.

Figure 8. George B. Kauffman's first book, dedication, 1966. (Courtesy, Springer-Verlag.)


Kauffman marks 50th joint paper

A paper on "The Resolution of Racemic Acid: A Classic Stereochemical Experiment for the Undergraduate Laboratory," which appears in the November Journal of Chemical Education, is something of a milestone for George B. Kauffman, professor of chemistry at Fresno State University.

The paper based on research carried out by Kauffman and Robin D. Myers, a senior chemistry major from Hanford, when Myers was still a freshman, is the 50th paper that Kauffman has co-authored with his students.

The author of five books and more than 250 papers, reviews, and articles on chemistry, education, and the history of science, Kauffman believes that the only way for students to learn how to do research and to think creatively is to actually participate in research.

His most recent paper is the tenth in a series of laboratory experiments designed specifically for undergraduate students. Kauffman said it enables an average freshman student to carry out one of the truly classic experiments of all time — the resolution of racemic acid, a form of tartaric acid—whereby Louis Pasteur showed that molecules of certain substances can exist in both right-handed and left-handed forms.

The separation of these crystals, carried out with the aid of a microscope and a pair of tweezers, led to Pasteur's concept of molecular asymmetry and to the founding of a special branch of chemistry—stereochemistry — the study of the spatial arrangement of atoms in molecules.

KENNETH BARCLAY, 15, works on a chemistry lab experiment at Fresno State University in conjunction with his research work with George B. Kauffman (right), professor of chemistry. Looking on are FSU chemistry students Steve Abbott (left rear) of Fresno and Robin Myers of Hanford

Figure 9. Fiftieth paper with students. Steven F. Abbott, Kenneth Barclay (age 15), Robin D. Myers, and George B. Kauffman (left to right). *The Fresno Guide*, December 10, 1975.


Chemist Sweeps Convention Prizes

AWARD WINNERS — Senior chemistry major Robert Pinnell second from right) discusses details of his award winning research work with assistant professor of chemistry, Dr. George B. Kauffman (left) and fellow prize winners Roland Majors, Melvin Lindbeck and Gary Anderson. FSC walked off with four of eight top awards at an annual chemistry convention in San Francisco.

Fresno State College chemistry majors walked off with four of the eight prizes awarded for outstanding papers presented at the 11th annual regional convention of the Student Affiliates of the American Chemical Society in San Francisco.

The winners placed FSC first among the 11 colleges and universities from California and Nevada represented at the weekend meeting. University of California entries won three prizes and the College of the Pacific one prize. FSC was the only state college to place among the winners.

Robert P. Pinnell, a senior, won first prize for his research paper on "The Separation of Geometric Isomers of Divalent Platinum by Chromatographic Adsorption." His paper was based on work done under research grants awarded recently to Dr. George B. Kauffman, assistant professor of chemistry, by Research Corporation and the National Science Foundation.

Gary Anderson and Ronald Majors, both freshmen, won second prizes for "Nitro and Nitrito Cobalt (III) Complexes" and "Pseu-

(Continued on Page 2)

Figure 10. Chemistry Majors Win SAACS Awards. George B. Kauffman, Ronald Majors, Melvin Lindbeck, Robert P. Pinnell, and Gary L. Anderson (left to right). *The Daily Collegian* (*Fresno State College*), April 27, 1960. (Courtesy, *The Daily Collegian.*)

Washington University School of Medicine, and Senior Clinical Research Physician at Novartis. Another high school student of the same age, Kenneth Barclay (Figure 9), also worked with me.

As longtime Faculty Advisor of the Fresno State College Student Affiliates of the American Chemical Society, I've been able to keep in contact with former students. In this capacity I also coached and rehearsed my student researchers in their prize-winning presentations for meetings and conventions. For example, in April, 1960 four of our chemistry majors walked off with four of the eight top awards for outstanding research papers presented at the 11th Annual Regional Convention of the Northern California-Nevada District of the SAACS in San Francisco (Figure 10). Robert P. Pinnell, a senior, won first prize, while Gary L. Anderson and Ronald Majors, both freshmen, won second prizes. FSC was the only state college to place among the winners. At other meetings my research students Dwaine O. Cowan and Larry A. Teter won second prizes.

Graduate Studies

In June, 1951 I graduated from Penn with honors in chemistry, and, although I received offers of teaching assistantships from Purdue and Indiana universities, I chose to work under Professor Joseph H. Simons, the famous fluorine chemist [4], at the University of Florida in Gainesville for two reasons. First, Professor Simons, whom we called "Uncle Joe" (not to his face, of course), offered me a research assistantship rather than a teaching assistantship, and second, I could begin work immediately instead of waiting until September (Figure 11). The Korean War was then in progress, and although I had a student deferment, in keeping with the maxim, "Why take chances?," I decided not to expose myself to the draft even during the summer.

My research with Uncle Joe was going nowhere so I prevailed upon Professor John Franklin Baxter, Jr. (Figure 12) [5], who had the reputation of being a rigorous, no-nonsense teacher to accept me as his first—and as it turned out—only graduate student. I felt that I needed such a mentor if I was ever to complete graduate school. John was 1961 Chairman and an active member of the ACS Division of Chemical Education. An early pioneer in television education, from 1959 to 1961 he conducted the popular "Modern Chemistry" course on NBC-TV's "Continental Classroom," which won him the ACS's 1962 James T. Grady Award for Interpreting Chemistry for the Public. As one of his TAs, I attended all his General Chemistry lectures and absorbed his philosophy, values, and methods. Like John, I've always taken my General Chemistry duties very seriously, and he served as my lifelong role model. In 1962 he received the Manufacturing Chemists Association Catalyst Award in the Teaching of College Chemistry. He was very proud of me when I followed in his footsteps and won the same award in 1976 (Figure 13).

I worked on ion exchange studies of fluoride complexes [6], and, because radioisotopes were necessary in this work, I spent the summer of 1955 working as a Research Participant at the Oak Ridge National Laboratory in the group of Kurt A. Kraus, who had been a fellow graduate student with John Baxter at the Johns Hopkins University. (Notice the importance of what is now called "networking.") During my stay at ORNL, I began my correspondence with Professor Aaron J. Ihde of the

University of Wisconsin, who has encouraged me in my studies in the history of chemistry throughout my career.

During the academic year 1955–56 I became Instructor in the Chemistry Department at the University of Texas, Austin, where Norm Hackerman, who had been an Instructor at Loyola College, Baltimore with John Baxter, was Chairman (networking again). That year I received the first of my four grants from Research corporation, “Measurement of the Anion Exchange Distribution Coefficients on Dowex 1 of the System: Fe(III)—KF — HF,” a continuation of my doctoral dissertation research. On January 28, 1956, I returned to Gainesville to receive my doctorate (Figure 12).

I spent the summer of 1956 as a research chemist at the Humble Oil and Refining Company in Baytown, Texas, where I worked on platinum catalysts [7] and learned about the dangers of heating volatile compounds in sealed tubes [8]. In September 1956, I became Assistant Professor of Chemistry at Fresno State College, now California State University, Fresno. I spent the summers of 1957 and 1959 as a research chemist at the Aircraft Nuclear Propulsion Department of the General Electric Company in Cincinnati, Ohio (Figure 14), where I distinguished myself by leaving my classified laboratory notebook overnight on a desktop, thus endangering the entire future of the Free World.

Coordination Chemistry

While still at the University of Texas and acting on a suggestion of Professor George W. Watt [9], I began work on the column chromatographic separation of geometrically isomeric coordination compounds on Linde Molecular Sieves [10]. After my move to FSC my students and I extended the work to include other adsorbents and other techniques such as thin-layer chromatography [11] and structural studies with support of grants from Research Corporation, the National Science Foundation, and the ACS Petroleum Research Fund. These studies were carried out by a small group of enthusiastic, dedicated students from my General Chemistry, Advanced Inorganic Chemistry, or Independent Study courses, some of which were my age or older. Notable among these students were Gary L. Anderson, Dwaine O. Cowan, Louis A. Dee, Richard A. Houghten, Jr., Edward V. Lindley, Jr., Robert K. Masters, Robin D. Myers, Louis B. Pankratz, Robert P. Pinnell, Nobuyuki Sugisaka, Larry A. Teter, Lloyd T. Takahashi, and James Hwa-san Tsai, some of whom I’ll mention later.

As any researcher knows, one investigation usually leads to another. Our separation studies led us to carry out structural determinations of one of the complexes that we separated. In all of our chromatographic column separations of square planar nonelectrolytic isomers of platinum(II) in nonaqueous solutions we found that the more polar *cis* isomers were adsorbed more strongly on polar adsorbents than were the less polar *trans* isomers. However, we encountered an apparent exception to this behavior with a hexacoordinate octahedral complex—the two supposedly stereoisomeric forms of trichlorotris(diethyl sulfide)iridium(III), $[IrCl_3\{(C_2H_5)_2S\}_3]$ — which suggested to us that the configurations assigned by the original investigators on the basis of color alone might be incorrect. The yellow isomer, suposedly *cis* or *fac* (1,2,3), was readily eluted with chloform from a silica gel column, whereas the red isomer, supposedly *trans* or *mer* (1,2,6), required the more polar solvent ethanol for elution.

From an interpretation of spectra alone it appeared as if the original investigators [12] were correct in their assignment of configuration. However, I often point out to my students that it is risky to base conclusions on the results of only one method and that a conclusion will more probably be correct if supported by results obtained from a number of independent methods. Therefore James Hwa-san Tsai (Figure 15) of Taiwan, my first foreign student collaborator and coauthor on ten papers, who went on to become the President of chemical companies in Taiwan and Hong Kong and the Research Director of another, obtained data by a variety of independent chemical and physical measurements—dipole moments; electrolytic conductances; electrophoresis; preparation of derivatives; syntheses of new compounds; absorption, reflectance, infrared, and NMR spectra; x-ray patterns; optical properties; and chromatographic behavior. The pieces of the puzzle began to fit into place, and it slowly dawned on us that the configurational assignment of one of the compounds was completely incorrect, an incident that illustrates not only the danger of relying on one criterion for a proof of structure but also the danger of accepting uncritically results reported in the published literature. The yellow form was indeed found to be the nonelectrolytic *cis* isomer;. however, the red form turned out to be not the stereoisomeric *trans* isomer but a salt—an electrolytic polymerization isomer, *trans*-$[IrCl_2\{(C_2H_5)_2S\}_4]$ *trans*-$[IrCl_4\{(C_2H_5)_2S\}_2]$ [13].

Jim Tsai and I are especially proud of this work, which was coauthored with Christian Klixbüll Jørgensen and Robert C. Fay. We treasure the report of one of the referees (Figure 16):

> This paper is one of the most thoroughly documented articles I have ever had the privilege to read. It has shown by a marvelously variegated number of techniques, both old and new, how a structure can be narrowly circumscribed without a final (most times extremely difficult) x-ray structure analysis. The authors are to be warmly congratulated on such a fine piece of work. Would there be more such careful research done today instead of the slipshod work that passes for research. I most heartedly recommend its speedy publication in *Inorganic Chemistry*.

I should mention that this referee’s report is not typical of those that I’ve received through the years. Perhaps that’s why I’ve saved it.

Inorganic Syntheses

One of the commonest errors of beginning undergraduate researchers in their choice of a problem is to take on too much—”to bite off more than they can chew.” Such a project is usually not continued to completion and can become a source of frustration and discouragement. Instead, the problem should be chosen from the viewpoint of the student, not the supervising professor. My late colleague and mentor Mel Gorman’s advice is particularly appropriate here:

To a seasoned investigator, the mere synthesis of a new compound without further investigation of its structure, thermodynamic properties, use as an intermediate, etc., would indeed be quite trivial, but to the embryo chemist, the knowledge that he has made such a compound never

Figure 11. George B. Kauffman working in Reed Laboratory, University of Florida, Gainesville, 1951. (Courtesy, George B. Kauffman.)

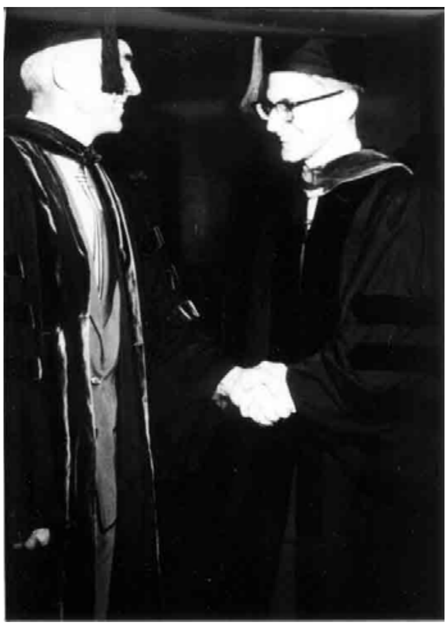
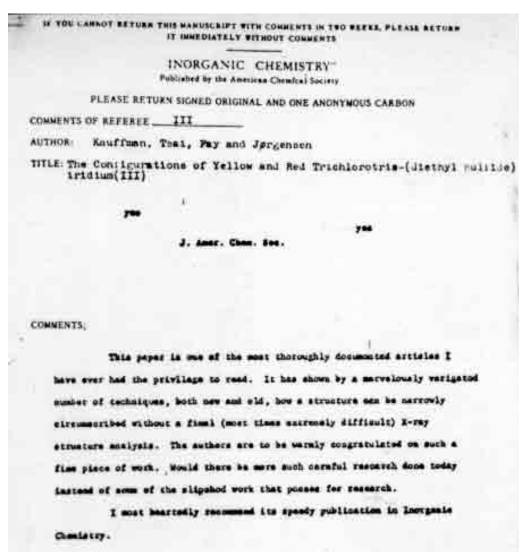


Figure 12. John F. Baxter (left) congratulates George B. Kauffman (right) on receiving his doctorate, University of Florida, Gainesville, January 28, 1956. (Courtesy, George B. Kauffman.)

Figure 13. Manufacturing Chemists Association Catalyst Award For Excellence in College Chemistry Teaching, Medal, 1976. (Courtesy, George B. Kauffman.)

Figure 14. Visiting Professors, General Electric Co. Aircraft Nuclear Propulsion Department, Cincinnati, Ohio. George B. Kauffman (left) discusses his seminar with Stancil S. Cooper (right), summer, 1957. (Courtesy, George B. Kauffman.)

Figure 15. James Hwa-San Tsai, George B. Kauffman, and Eishin Kyuno (Kanazawa University) (left To right), 10th International Conference on Coordination Chemistry, Nikko, Japan, September, 1967. (Courtesy, George B. Kauffman.)



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INORGANIC CHEMISTRY

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COMMENTS OF REFEREE III

AUTHOR: Kauffman, Tsai, Fay and Jørgensen

TITLE: The Configurations of Yellow and Red Trichlorotris-(diethyl sulfide) iridium(III)

yes

yes

J. Amer. Chem. Soc.

COMMENTS:

This paper is one of the most thoroughly documented articles I have ever had the privilege to read. It has shown by a marvelously varigated number of techniques, both new and old, how a structure can be narrowly circumscribed without a final (most times extremely difficult) X-ray structure analysis. The authors are to be warmly congratulated on such a fine piece of work. Would there be more such careful research done today instead of some of the slipshod work that passes for research.

I most heartedly recommend its speedy publication in Inorganic Chemistry.

Figure 16. Referee's report, *Inorganic Chemistry*, 1963 [13]. (Courtesy, George B. Kauffman.)

before prepared gives a tremendous lift to his scientific ego [14].

But I would go a step beyond Mel and point out that to the novice researcher any compound is "new." Also, as most of us can testify, without careful attention to crucial details, which are often not specified in the literature, particularly the older literature, the preparation of known compounds is rarely foolproof or reproducible; therefore, at the Fall 1933 meeting of the American Chemical Society, five prominent inorganic chemists decided that there was a need for a series of volumes giving detailed, independently tested methods for the synthesis of inorganic compounds similar to *Organic Syntheses*. John C. Bailar, Jr. (Figure 17) [15], the "father of American coordination chemistry" and first Chairman of the ACS Division of Inorganic Chemistry (1957), joined the Editorial Board of the new journal, *Inorganic Syntheses*, the first volume of which appeared in 1939. An active participant and motivating force in its affairs, contributing 16 syntheses, checking 5 others, and serving as Editor-in-Chief of Volume IV (1953), John, in addition to counseling me in the stereochemistry of coordination compounds (Figure 18), motivated me to contribute 30 syntheses and check 9 others with the aid of my students.

Inorganic Syntheses fit into my research program in the following way. Although adsorption chromatography had been used to separate a variety of isomeric organic substances, at that time the technique had been applied to only a limited number of inorganic isomers. Because ideal isomer pairs for separation should be inert so as to minimize isomerization, we began our separations using coordination compounds of the platinum group metals, especially platinum, iridium, rhodium, and palladium. In the course of our work we developed reproducible syntheses for more than two dozen such compounds, resulting in no less than 15 articles published in *Inorganic Syntheses* during the period 1960–1966. Because much of the pioneering work on the platinum metals, one of Russia's foremost natural resources, was carried out by Russian chemists, I directed my historical interests to a series of studies of these men, which continues to this day. For these works I was awarded all three bronze medals and memorial diplomas by the N. S. Kurnakov Institute of General and Inorganic Chemistry of the USSR Academy of Sciences—L. A. Chugaev (1976), N. S. Kurnakov (1990), and I. I. Chernyaev (1991)—an honor that I hold in common with John Bailar (Figure 19). On the occasion of my 70th birthday the S. I. Vavilov Institute for the History of Science and Technology, Russian Academy of Sciences honored me with a laudatory decree for my contributions to chemistry and its history.

The very first of our inorganic syntheses [16] exemplifies my constant admonition to students that they should not reject ideas regardless of the source. Ideas that come to us from our subconscious need not necessarily be of the earthshaking variety that would not occur to us through our usual conscious thought processes. Bob Pinnell (Figure 10), now Professor of Chemistry in the Joint Science Department of Claremont McKenna, Pitzer, and Scripps Colleges, and I were trying to devise a reproducible preparation for copper(I) iodide because the commercial product is often contaminated with adsorbed iodine:

$$2CuSO_4 + 4KI \rightarrow 2CuI + 2K_2SO_4 + I_2$$

We found that extracting the iodine formed in the reaction *after* the product was formed was an inefficient, tedious, and incomplete process. One morning I awoke with the simple expedient of adding sodium thiosulfate to react with the iodine *before* it is liberated:

$$2CuSO_4 + 4KI + 2Na_2S_2O_3 \rightarrow 2CuI + 2K_2SO_4 + Na_2S_4O_6 + 2NaI$$

No doubt I would have eventually reached this obvious conclusion by more conventional conscious thought processes. However, the point is that I did not.

A Citation Classic

In 1987 the Institute for Scientific Information (ISI) designated one of our syntheses, that of *cis*- and *trans*-diamminedichloroplatinum(II) [17], a "Citation Classic"—"one of the most frequently cited works in its field" (Figure 20)[18]. These isomers played an important role in the historical development of Werner's coordination theory, being the earliest examples proposed for his square planar configuration for platinum(II) [19]. Our synthesis undoubtedly owes its frequent citation in the literature to the fact that since Barnett Rosenberg's pioneering work [20], the *cis* isomer ("cisplatin") has found increasingly important use in the treatment of cancer.

Ironically, we found these isomers to be unsuitable in developing our separation method because of their limited solubilities in nonpolar solvents. My student coauthor, Dwaine O. Cowan (Figure 21), Professor Emeritus of Chemistry at the Johns Hopkins University and 1995 CSUF Outstanding Alumnus, went on to design, synthesize, and characterize the first "organic metal" (TTF-TCNQ). Dwaine became an internationally recognized authority on organic solid state chemistry, organometallic chemistry, organic photochemistry, electron transfer redox reactions, and synthesis of sulfur, selenium, and tellurium heterocyclic compounds [21].

I don't want to give the impression that all our synthetic efforts were successful. Despite fine work by Richard A. Houghten, Jr. (Figure 1) and Jerry L. Sarquis (Figure 1), now Professor of Chemistry and Secretary/Councilor of the ACS Division of Chemical Education, our attempts to synthesize cobalt and chromium complexes first prepared by Werner and Sophus Mads Jørgensen were fruitless. Also, a reproducible synthesis for Werner's long-sought ammonia-violeo salts, *cis*-$[CoCl_2(NH_3)_4]X$ (*cis*-tetraamminedichlorocobalt(III) salts [22], so crucial in proving his octahedral configuration for hexacovalent cobalt(III), still continues to elude us to this day although numerous students in several of my Advanced Inorganic Chemistry classes have employed three different methods in our unfulfilled quest.

Laboratory Experiments

To date 23 of our laboratory experiments have appeared in the *Journal of Chemical Education* and the *Journal of College Science Teaching* [23–30]. These cover a wide range of topics. One of our experiments, "Syntheses and Titrations of Unknown Acids" [Figure 22) [31a], with former student, Richard A. Houghten, Jr. (Figure 23), one of the founders of

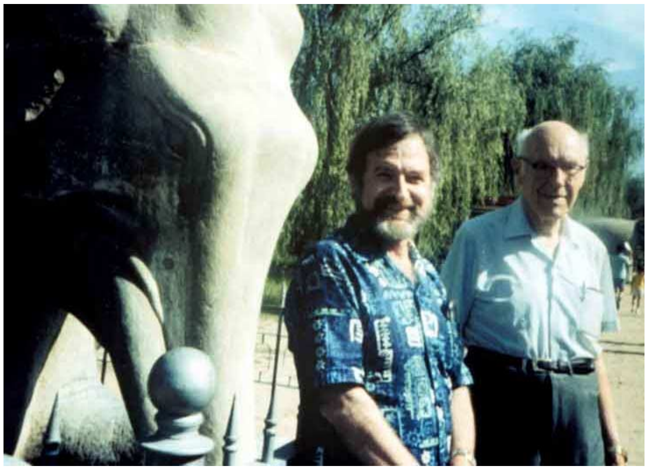

Figure 17. George B. Kauffman (left) and John C. Bailar, Jr. (right) sightseeing somewhere in China, following the XXV International Conference on COORDINATION Chemistry, Nanjing University, August 1987. Photograph by Laurie M. Kauffman. (Courtesy, Laurie Kauffman.)

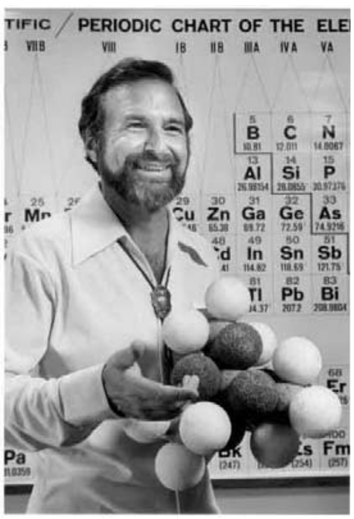

Figure 18. George B. Kauffman uses molecular models in lecture to teach stereochemistry. (Courtesy, CSUF Academic Innovation Center.)


АКАДЕМИЯ НАУК СССР

ИНСТИТУТ ОБЩЕЙ
И НЕОРГАНИЧЕСКОЙ ХИМИИ
им. Н. С. КУРНАКОВА

ОРДЕНА ЛЕНИНА
ИНСТИТУТ
ОБЩЕЙ
И
НЕОРГАНИЧЕСКОЙ
ХИМИИ
имени
Н. С. КУРНАКОВА
решением Ученого совета
в связи с 50-летием открытия
И. И. ЧЕРНЯЕВЫМ
закономерности трансвлияния
в координационных соединениях
награждает
юбилейной медалью
«АКАДЕМИК
ЧЕРНЯЕВ
ИЛЬЯ ИЛЬИЧ»

Директор
академик
Ю. А. ЗОЛОТОВ

Дата

Figure 19. George B. Kauffman's Il'ya Il'ich Chernyaev Medal Diploma, 1991. (Courtesy, George B. Kauffman.)

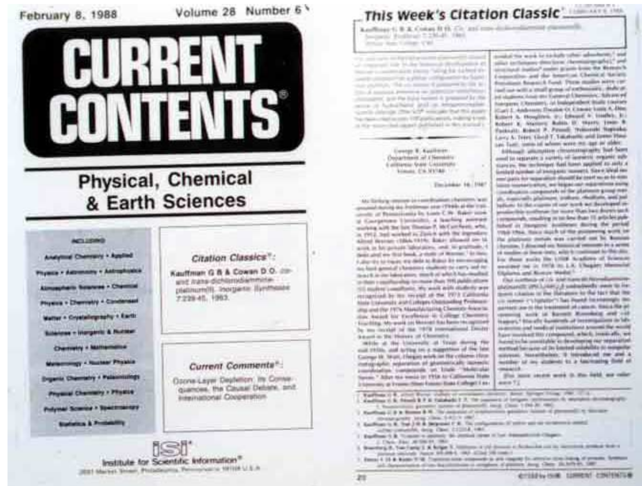
February 8, 1988 Volume 28 Number 6

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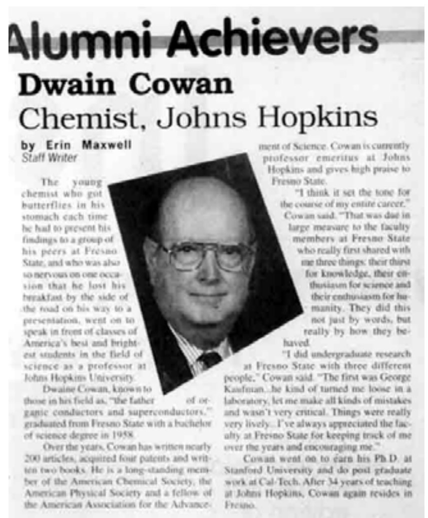
Figure 20. George B. Kauffman and Dwaine O. Cowan, Citation Classic [18]. (Reprinted with permission from ISI from *Current Contents*.)


Alumni Achievers

Dwain Cowan

Chemist, Johns Hopkins

by Erin Maxwell
Staff Writer

The young chemist who got butterflies in his stomach each time he had to present his findings to a group of his peers at Fresno State, and who was also so nervous on one occasion that he lost his breakfast by the side of the road on his way to a presentation, went on to speak in front of classes of America's best and brightest students in the field of science as a professor at Johns Hopkins University.

Dwaine Cowan, known to those in his field as, "the father of organic conductors and superconductors," graduated from Fresno State with a bachelor of science degree in 1958.

Over the years, Cowan has written nearly 200 articles, acquired four patents and written two books. He is a long-standing member of the American Chemical Society, the American Physical Society and a fellow of the American Association for the Advancement of Science. Cowan is currently professor emeritus at Johns Hopkins and gives high praise to Fresno State.

"I think it set the tone for the course of my entire career," Cowan said. "That was due in large measure to the faculty members at Fresno State who really first shared with me three things: their thirst for knowledge, their enthusiasm for science and their enthusiasm for humanity. They did this not just by words, but really by how they behaved.

"I did undergraduate research at Fresno State with three different people," Cowan said. "The first was George Kaufman...he kind of turned me loose in a laboratory, let me make all kinds of mistakes and wasn't very critical. Things were really very lively...I've always appreciated the faculty at Fresno State for keeping track of me over the years and encouraging me."

Cowan went on to earn his Ph.D. at Stanford University and do post graduate work at Cal-Tech. After 34 years of teaching at Johns Hopkins, Cowan again resides in Fresno.

Figure 21. Dwaine O. Cowan, *Insight* (California State University, Fresno), 1995.

Figure 22. George B. Kauffman, Robert L. Masters, and Dee Dalton (right to left) watch Richard A. Houghten, Jr. perform a titration, about 1967. (Courtesy, George B. Kauffman.)

combinatorial chemistry, CEO of four research companies, and recipient of the 1997 CSUF Alumni Award of Excellence, was used for many years in our General Chemistry laboratory course and published in The Freeman Library of Laboratory Separates in Chemistry [31c]. It was also selected from the more than a thousand experiments that appeared in the *Journal of Chemical Education* during the period 1940–1967 for reprinting in the book *Modern Experiments for Introductory College Chemistry*, described by the editors as a collection of "samplings of the provocative ideas of some of the world's most imaginative professors of chemistry" [31b].

Another of our experiments involved the unusual metallo complexes, in which the central atom is not a metal but rather a nonmetal such as sulfur, iodine, oxygen, nitrogen, etc., while the ligands contain metal atoms [32], such as $[Ag_3S]NO_3$ [33]. It was coauthored with Günter Bergerhoff, now Professor Emeritus of Chemistry at the Universität Bonn, and CSUF student Mohammad Karbassi, formerly a Research Scientist in the Department of Surgery, New England Deaconess Hospital, Boston and currently a physician at the Deaconess Clinic in Billings, Montana.

Classic Experiments

I've been able to combine my interest in the history of chemistry with my interest in laboratory experiments by adapting classic historic experiments to provide reproducible experiments for the undergraduate laboratory. Most of these required considerable modification to achieve results, and we often added our own variations, using modern techniques not available to the original discoverers.

The first classic that we adapted was Alfred Werner's resolution of the *cis*-amminebromobis(ethylenediamine)-cobalt(III) ion (*cis*-$[CoBrNH_3\{NH_2(CH_2)_2NH_2\}_2]^{2+}$) [34], which led directly to his becoming the first Swiss Nobel laureate for chemistry in 1913. Edward V. Lindley, Jr., now Chairman of the Chemistry Department at Fresno City College and recipient of the 1997 Gerald C. Hayward Award for Excellence in Education of the California Community Colleges Board of Governors, was the student coauthor on this experiment [35].

Another classic was Louis Pasteur's mechanical resolution of racemic acid [36], which led to the founding of stereochemistry and influenced research in a number of fields. Robin D. Myers (Figure 24), the coauthor on this [37] and eleven other papers, including a translation of Pasteur's classic paper [38], went on to become a Computer Scientist at the Lawrence Livermore Laboratory, Principal Engineer at Versatec, Senior Scientist at Apple Research Laboratories, and an independent consultant in color science and imaging. Our photograph of the actual enantiomeric crystals (Figure 25) has appeared in a number of chemistry textbooks.

A classic that we adapted [39] on the occasion of the sesquicentennial of the original experiment [40] was Friedrich Wöhler's synthesis of urea ($CO(NH_2)_2$) from ammonium cyanate (NH_2CNO). Coauthor Steven H. Chooljian (Figure 26) later received his M.D. degree from the University of California, Los Angeles Medical School. A highly regarded Fresno specialist in internal medicine, he is now my wife's and my personal physician.

Historical Studies

I took my only formal course in the history of chemistry from the late Claude K. Deischer, active in the ACS HIST Division for many years, who made a great impression on me. Also, Mel Gorman, longtime Professor of Chemistry at the University of San Francisco, whom I mentioned previously, mentored me in the history of science from our first meeting at the Spring 1958 ACS Meeting in San Francisco until his death.

My first article on the history of chemistry, a brief biography of Belgian fluorine chemist Frédéric Swarts (Figure 27) [41], appeared while I was still a graduate student so it should come as no surprise that 31 of my papers with students have involved history. These have dealt with the life and work of such chemists as James Lewis Howe, Il'ya Il'ich Chernyaev, Alfonso Cossa , Chaim Weizmann, and the pseudochemist, the Comte de Saint-Germain; contributions of ancients and alchemists; jade in Chinese alchemy; and a history of the CSUF Chemistry Department.

The all-time publication record for a single Kauffman student coauthor to date (16 publications), is held not by a chemistry major but by a psychology major and former television producer, Isaac Mayo, who is now at Cornell University's College of Veterinary Science. After an examination on which I asked students to balance several redox equations, Isaac wrote me a one-page note, complaining that I had said that redox reactions would not be included on the exam, a misunderstanding on his part. I was amazed by the quality of his writing and asked him if he wished to collaborate on a number of topics on which I been unable to find the time to write. He agreed, and in addition to historical topics we also interviewed contemporary chemists such as Nobel laureates Linus Pauling [42], Melvin Calvin [43], and Glenn T. Seaborg (Figures 28–30). One of our articles [44] on the shape-retaining alloy Nitinol, "The Metal with a Memory" [45], was chosen by Forbes, Inc. of New York from the hundreds of articles that have appeared through the years in *American Heritage of Invention & Technology* for inclusion in a special collection of six articles sent as a premium to all new subscribers to the magazine.

Lecture Demonstrations

When former students return to visit, they invariably recall my lecture demonstrations, usually of the more spectacular or dangerous variety, even though more than four decades have elapsed (Figure 31). At the beginning of each semester, I customarily ask students in my General Chemistry class to volunteer to prepare lecture demonstrations. Not only do they learn chemistry, but they also gain experience in public speaking, for I have them make the actual presentation before the class.

My first publication with a student was a short note [46] coauthored with Charles R. Hall, who, after graduation, became our Storeroom Supervisor. Like many of our publications, it was basically the result of a simple idea. Instability has prevented the advance preparation of large quantities of solutions for the iodine clock reaction, one of my favorite demonstrations since I first saw it as an adolescent at a science demonstration on the Boardwalk in Atlantic City, New Jersey. In our modification, instead of adding the sulfuric acid to the sodium sulfite/starch solution, we either added it to the

Figure 23. Award-winning student. George B. Kauffman (left) congratulates Richard A. Houghten, Jr., who holds his San Diego Section, American Chemical Society's 1997 Distinguished Scientist Award plaque, San Diego, March 13, 1997. (Courtesy, George B. Kauffman..)

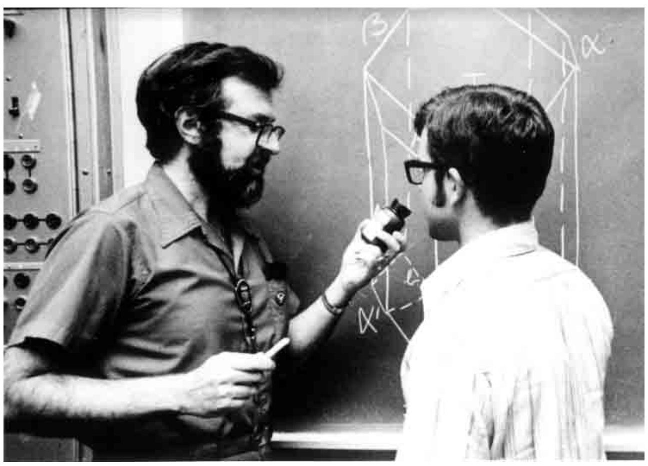


Figure 24. George B. Kauffman (left) explains the structure of racemic acid to Robin D. Myers (right), 1975. (Courtesy, George B. Kauffman.)

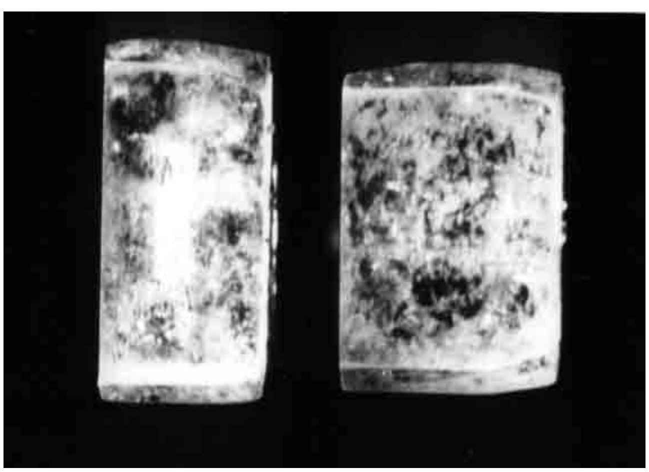
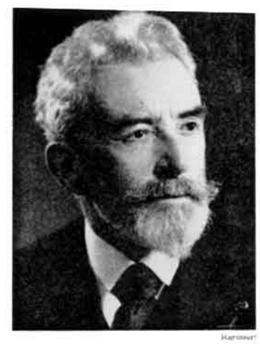


Figure 25. Crystals of *d*- and *l*-Tartaric Acid [37]. (Courtesy, George B. Kauffman.)

Figure 26. Steven H. Chooljian, MD, Mid-1990s. (Courtesy, George B. Kauffman.)



Frédèric Swarts

FRÉDÉRIC SWARTS: PIONEER IN ORGANIC FLUORINE CHEMISTRY

GEORGE B. KAUFFMAN
University of Florida, Gainesville, Florida

Figure 27. Frédéric Swarts (1866–1940). (Used with permission from the *Journal of Chemical Education*, Vol. 32, No. 6, 1955, p 301; copyright 1955, Division of Chemical Education, Inc.) [41].

Figure 28. Nonagenarian Nobel Laureate Linus Pauling (left), who spoke at the Coordination Chemistry Centennial Symposium, chats with symposium organizer George B. Kauffman (right), 205th National Meeting, American Chemical Society, Denver, Colorado, March 29, 1993. Photograph by Ernest Carpenter. (Courtesy, American Chemical Society.)

Figure 29. Nobel Laureate Melvin Calvin (center) in his University of California, Berkeley office (Latimer Hall 602) during an interview with George B. Kauffman (left) and Isaac Mayo (right), July 28, 1993. (Courtesy, George B. Kauffman.)

Figure 30. Nobel Laureate Glenn T. Seaborg (center) in his Lawrence Berkeley laboratory office during an interview with George B. Kauffman (right) and Isaac Mayo (left), July 28, 1993. (Courtesy, George B. Kauffman.)

Figure 31. Sodium-water explosion outside Mclane Hall, California State University, Fresno (one of many such demonstrations), 1970s [47]. (Courtesy, CSUF Academic Innovation Center.)

Figure 32. Mole demonstration, 1987 [54]. (Courtesy, George B. Kauffman.)

Figure 33. George B. Kauffman demonstrates the crystallization of a supersaturated solution of sodium acetate, *The Daily Collegian* (California State University, Fresno), 1966 [51]. (Courtesy, *The Daily Collegian*.)

Figure 34. Debbie Olivia Diaz (right) shows George B. Kauffman (left) how lithium carbonate precipitates from a saturated solution on warming [65]. (Courtesy, Randy Vaughn-Dotta, photographer.)

Table 1. Chronological List of Student Coauthors and the Numbers of Their Papers

1. Charles R. Hall, 2	20. Edward V. Lindley, Jr., 2	38. Michael J. Sinwell, 1	56. Jonathan Buchanan, 1
2. Robert P. Pinnell, 5	21. Gary L. Anderson, 2	39. Steven H. Chooljian, 4	57. Ester Molayem, 2
3. Larry A. Teter, 6	22. Stanley E. Gordon, 1	40. Robert J. Broughten, 2	58. Stewart W. Mason, 1
4. Dwaine O. Cowan, 4	23. Michael F. Citro, 1	41. Robert Toll, 2	59. Kin Sing Yen, 4
5. Jerome S. Blank, 1	24. Leslie W. Michael, 1	42. Lawrence Y. Fang, 1	60. Debbie Olivia Diaz, 4
6. Lloyd T. Takahashi, 8	25. Shan Yaw Lee, 1	43. Christine Miller, 1	61. Scott D. Pennington, 3
7. James Hwa-san Tsai, 10	26. Lily Hu Chow, 1	44. Leo Kim, 1	62. Isaac Mayo, 16
8. Kenneth L. Stevens, 2	27. Robin D. Myers, 12	45. Dean F. Marino, 1	63. Malrubio Cabrera II, 1
9. Nobuyuki Sugasaka, 5	28. Brian D. Stedjee, 5	46. Mohammad Karbassi, 5	64. Rocky Dean Gipson, 1
10. Guillermo Acero, 1	29. Robert Epperson, 1	47. Jack D. Jackson, 3	65. Eric Alvin Haynie, 1
11. Richard A. Houghten, Jr., 4	30. Wayne Craig, 2	48. Ronald D. Ebner, 6	66. Brian Ampère Smith, 1
12. Gary Foust, 1	31. Johanna Koob, 3	49. John Hagopian, 3	67. Ching Kin Yim, 1
13. Peggy Tun Yin, 1	32. Davey Faoro, 1	50. Craig A. Ferguson, 3	68. Judith M. Reposo, 1
14. Paul F. Vartanian, 2	33. Steven F. Abbott, 1	51. Paul S. Chin Sang, 1	69. Mario L. Reposo, 1
15. Richard A. Albers, 2	34. Stephen E. Clark, 1	52. Mark A. Gilmore, 1	70. Likins, Robert E., 1
16. Fred L. Harlan, 2	35. John M. Gibson, 1	53. Philip Chu, 1	71. Philip L. Posson, 1
17. Zie Anna Payne, 5	36. Robert K. Masters, 1	54. Scott D. Stringer, 2	72. Hiram William Blanken, 2
18. Russell Fuller, 1	37. Paul R. Schabinger, 1	55. Matthew L. Adams, 6	73. Rowena Rege, 1
19. James Felser, 1			

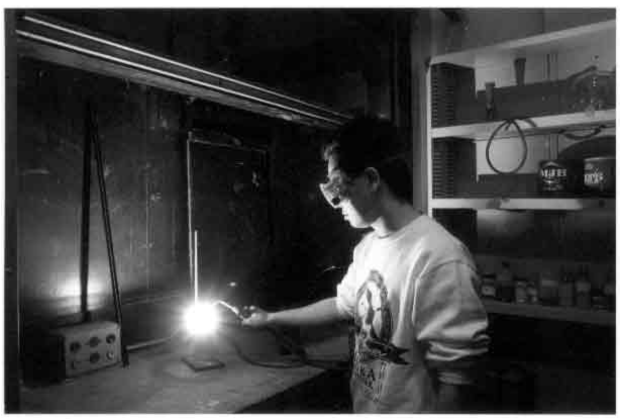


Figure 35. Kin Sing Yen demonstrates the limelight [64]. (Courtesy, Randy Vaughn-Dotta, photographer.)

Figure 36. George B. Kauffman's study cards (Analytical Chemistry, Qualitative Analysis, and Mineralogy), University of Pennsylvania, April 1949. (Courtesy, George B. Kauffman.)

potassium iodate solution or added it separately at the time of the demonstration as a third solution. In both cases, after standing for as long as a year, these solutions still produced sharp color changes. In the course of our work we found that a fungus, identified as *Phycomyces nitens*, could grow in sulfuric acid solutions!

This was the first of 28 demonstrations published with students on a variety of topics (Figures 31–35) [47–68]. Three of these demos [50, 55, 57] were selected for reprinting in George Gilbert's book, *Tested Demonstrations in Chemistry and Selected Demonstrations from the Journal of Chemical Education*. Several of them—those with Debbie Olivia Diaz (Figure 34) [65] and Kin Sing Yen (Figure 35) [64]—were carried out during my service as a Faculty Research Mentor in CSUF's Minority Undergraduate Summer Enrichment (MUSE) program. None of them require exotic reagents or complicated apparatus, and they are especially suitable for use by instructors in colleges with limited facilities, equipment, or financial resources.

Book and Instructional Media Reviews

During my college years I utilized the time spent in hiking the five miles each way to the Penn campus either in memorizing operatic arias or in studying from cards containing lecture notes (Figure 36). I've continued this practice in modified form to the present day. Except for my weekly practice of hatha yoga, my sole regular exercise consists of every-other-day one-hour morning walks during which I manage to read and walk our dog, Vixen Kauffman. To date I've bumped into only a Winnebago and a boat trailer. For those who wonder how I've been able to review more than 700 books and articles, this is my secret *modus operandi*. Recently, I've also involved students in these reviews to instill in them the *pro bono publico* professional obligation of scientists to review new works in their field [69–72]. Because the younger generation is more knowledgeable about and adept about computers than I, I've tried to recruit them to review CD-ROMs and other electronic media for *The Chemical Educator* and other journals. This is an area in which I'm a relative novice but in which I'm slowly acquiring experience.

 S1430-4171(00)05415-3, Published on Web 10/02/2000, 10.1007/s00897000415a, 550277gk.pdf

Conclusion

In the Fall of 1979, while auditing a Poetry Writing course taught by Charles G. ("Chuck") Hanzlicek at CSUF, I wrote a poem [73] using the metaphor of my first coordination compound to summarize the changes in me during the course of my career and to pay tribute to my mentor Lou Baker:

Compound α: Ode to a Complex Salt

$$[CoCO_3(NH_3)_4]NO_3 \cdot 1/2H_2O$$

There and Back Again, Bilbo Baggins' original title for *The Hobbit*—J. R. R. Tolkien, *The Fellowship of the Ring*

It sits in a small, squat bottle on my office shelf,
A dull, brick-red, free-flowing powder,
Carefully labeled in a meticulous adolescent hand,
"Compound α, May 10, 1948."
First member of a growing collection of colorful substances,
Created with an endless parade of student protégés,
Now mature scientists scattered God knows where,
Today faceless names long since departed…
A partial payment of my debt to Lou.

The heavy metal fire door clanged shut behind us,
As Lou and I entered that part of the Harrison lab where freshmen never go.
In his apparatus-clogged office, bereft of human artifacts,
Save a solitary rose in a water-filled flask,
Through which the sunlight, the same glinting off his thick, rimless specs,
Cast a spectrum on the white pages of our prep book,
With growing excitement, we began our joint work.
He, the graduate assistant, towering over me, physically and intellectually,
And I, the admiring spellbound novice, obeying his commands and gesticulations;
Together we made the salt now gracing my shelf…
No wonder I dedicated my first book to him!

I used my work with Lou to write my first composition,
Breaking my defeatist conviction that I couldn't write prose;
Like Cyrano, I spoke in my own voice for the very first time.
Before, I had others write my English compositions;
I even copied one from a book (*Mea culpa*!).
It only earned a "B": Imagine that!
And now, years later, I turn to that first experiment again
To try my hand at poetry.

That salt was the color of dried blood,
Reason enough for me to make it.
I knew nothing of its properties, uses, or reactions,
Its crucial role in the coordination theory,
Erected single-handedly by Alfred Werner,
My future scientific hero, whose story I would someday tell,
After a year's ferreting out the tale from his *Nachlass*,
In Zürich, that quaint medieval town on the banks of the Limmat.

That sheltered Jewish boy from Philly
Never dreamed where that salt would lead him,
Surprising his most unrealistic fantasies,
Honored and lionized on three continents,
Presenting a seminar in the shadow of Berkeley's campanile,
Quizzed by a Nobel laureate;
Chairing a session in Moscow, while glancing out the window
At the gilded onion domes of Ivan the Terrible and Boris Godounov;
Lecturing in lush, rain-soaked Nikko,
Near the temple of the three monkeys
(See no evil, hear no evil, speak no evil);
All this swirled like a genie
From that little magic bottle.

Trapped within each molecule of carmine crystals,
Hidden to the eye, ear, nose, and tongue,
Invisibly sleep four molecules of ammonia,
Slumbering harmlessly for more than three decades,
Yet capable of expanding to liters of caustic, toxic gas
Upon the liberating touch of heat or chemicals.
The quintessence of stability…
I wish that I could be so stable!

And yet would I really want to trade my life today,
To be seventeen once more, awkward and uncertain,
Dreading the future, assuming the worst?
The salt still stands upon my shelf, unchanged by time,
Exactly the same in weight and color and form
As when I poured it into its container through a paper funnel,
Careful not to lose a grain of my precious prize;
Give 'Em Hell Harry was president then,
And a watergate was just an irrigation device.

***

Yes, the mutable boy has changed; the stable salt has not.
From a dead, inert compound he has forged his life.

In conclusion, I acknowledge the role of chance in my life and want to assure you that I didn't carry out these researches with students with any great plan or philosophy in mind. They were largely—to use the late English historian Arnold Toynbee's expression—"O.D.T.A.A."—one damned thing after another. My students and I merely followed where each successive problem led us. Our only secret—if there *is* a secret—is our persistence. And, if you follow our example, adapting our method to the specific conditions of your own particular institution, interests, and situation, you too can achieve the same results.

Acknowledgment. I am indebted to Randy Vaughn-Dotta of the CSUF Academic Innovation Center and Ernest Carpenter of the American Chemical Society's *Chemical & Engineering News* for their excellent photographic work.

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